



I claim:

1. (Amended) An apparatus for flow-pressure control and monitoring of constant or variable volume air-fluid distribution systems, terminal devices, and prime movers comprising

a primary mover (1) with variable speed control (7), including metering of voltage and amperage;

a means for measuring mover speed of rotation (RPM);

connecting ductwork or distribution system (the system) 5;

a cross-sectional housing with independent total, static, and velocity multi-point pressure sensors (2, 13, 14, 15) or simplified sensing probes consisting of total impact and static probes, where  $V_p$  may be derived from the deduction  $TP - SP = V_p$ , and wherein a Mover Total Pressure (20) may be applied by including a total impact sensor (13) at its inlet or intake;

a terminal control device (3), as with a damper or valve housing fitted with total impact, static, and velocity sensors (4, 13, 14, 15) and fitted with motor control actuation;

a heat exchanger housing (8), its air side fitted with dry and wet bulb air temperature sensors and fluid side fitted with fluid temperature sensors in and out of the heat exchanger along with a fluid control valve (3) on its return side piping;

an open port for an external input, zone sensor / thermostat, or other controlled source as may be set arbitrarily;

a signal processor (micro controller) (9) with an input from all temperature and pressure sensors (2, 4, 13, 14, 15) and output to motor control (7) and damper actuation (3);

an output to a panel display monitor (6) with a Cartesian graph indicating performance curve coordinates of the mover (11), the distribution system (5), and the terminal device (3); also including BHP data as factored from current readings; heat flow data from any heat exchange terminal (8).

(CLAIMS 2-125 HAVE BEEN CANCELLED)

126. (Amended) The step of maintaining adequate Total Pressure of claim 283, wherein TPR (Total Pressure Required) is monitored against its actual value, TPA (Total Pressure Available) at each terminal flow control device (3) sensing station (4), using only TPA in whatever amount available;

and modulating damper/valve position if TPA exceeds TPR at a given set point;

and maintaining damper/valve position at TPR set point for pressure independent operation (independent of the total system) under changing system conditions and changing valve constants until TPA drops below this point.

(CLAIMS 127-161 HAVE BEEN CANCELLED)

162. (Amended) The apparatus of claim 1 wherein the microprocessor (9) contains an expandable database reference

of known mover performance characteristics as established with said method;

of known mover characteristics as established through curve plotting by way of said method;

of known mover characteristics as established by other accepted means;

of known mover types, sizes, and capacities.

163. (Amended) The apparatus of claim 1 wherein the microprocessor (9) contains an expandable database reference

of known terminal device performance characteristics as established with said method;

of known terminal device characteristics as established through curve plotting by way of said method;

of known terminal device characteristics as established by other accepted means;

of known terminal device types, sizes, and ranges.

(CLAIMS 164-186 HAVE BEEN CANCELLED)

187. (Amended) The method of claim 287 where under parallel damper operation (19), the secondary parallel damper and additional flow source provide a cumulative velocity, traversing fitting and directional losses.

188. (Amended) The method of claim 286 wherein the primary damper (3) may provide critical run leverage by generating static pressure in conjunction with forced mover application (1) through motor-drive speed control (7), thus maintaining adequate Total Pressure.

(CLAIMS 189-194 HAVE BEEN CANCELLED)

195. (Amended) The method of claim 272 wherein leakage rate and quantity, or undue flow and quantity are deducted

by noting x value changes in the system curve plotted against any mover or terminal device and its respective system or sub-system reflecting relative increases in Velocity Pressure and, conversely, decreases in Static Pressure as deducted from Total Pressure.

196. (Amended) The method of claim 272 wherein undue restriction and quantity may be deducted

by noting y value changes in the system curve plotted against any mover or terminal device and its respective system or sub-system reflecting relative increases in Static Pressure and, conversely, decreases in Velocity Pressure as deducted from Total Pressure.

(CLAIMS 197-198 HAVE BEEN CANCELLED)

199. (Amended) The method of claim 272 wherein leakage testing operation may proceed by increasing mover speed (7) and

throttling the terminal device damper-actuator (3) until static sensor input (4) reaches the entered value of the duct rating;

stopping where SP and Vp solitary curves experience level off;

determining the exact percentage of Vp content as noted in sampled or real time flow-pressure readings;

displaying SP and Vp solitary curves with level-off plateaus, where each gradient is required to remain constant under testing conditions;

converting the Vp figure to FPM units across the adjusted area of only that section being isolated for testing to establish CFM leakage flow rate.

200. (Amended) The method of claim 272 wherein leakage testing operation may proceed by control damper throttling (3) and mover application (7);

bringing system Static Pressure level up to the ductwork rating and isolating its velocity gradient;

displaying plotted system curves (5) with actual operating points (10);

and calculating comparative data noting specific deviations from those operating points (10) intended.

201. (Amended) The method of claim 195 wherein leakage testing operation may proceed by

deducting the leakage factor under any given system conditions (5) through specific Vp gradient deviations from known OP's (10) that cannot be attributed to undue flow.

202. (Amended) The method of claim 272 wherein the interior volume of a given vessel or enclosure may be determined by instant reading whereby

a free flow rate is sampled prior to encountering total net static pressure;

marking this cutoff point in memory;

performing a calculating step to determine the interior volume of standard air passing this pivotal point through CFM flow-volume unitary measurement.

203. (Amended) The method of claim 202 wherein the method establishes the system curve (5) of a vessel or enclosure through precise instant flow readings using flow pressure sensing stations (2, 4).

204. (Amended) The method of claim 203 wherein free flow rate is monitored until build up of static resistance causes it to begin to cease;

marking in memory this exact cutoff point, wherein flow encounters maximum resistance - or total *static* power of the primary mover;

deriving the exact flow-volume rate that passed the metering device (2, 4) from CFM units, after  $V_p$  is converted to FPM.

(CLAIM 205 HAS BEEN CANCELLED)

206. (Amended) Furthering the method of claim 204, wherein the function will continue to monitor any static and dynamic factors present after the vessel has been filled to its full interior volume,

or more indicatively, when the primary mover (1) has reached its total static power, *less* the total static drop of the metering device (3), *less* any  $V_p$  which may exist in the form of leakage leaving the vessel at a steady rate.

(CLAIMS 207-218 HAVE BEEN CANCELLED)

219. (Amended) The method of claim 202 wherein ACH (Air Changes per Hour), ACM (Air Changes per Minute), or any unitary measurement of air-fluid changes occurring within a vessel, compartment, or enclosure is determined through applying the desired time frame to each complete change of volume constituting one standard change or any corrected change occurring above or below atmosphere.

(CLAIMS 220-271 HAVE BEEN CANCELLED)

272. (New) A method for flow-pressure control and monitoring of constant or variable volume air-fluid distribution systems, terminal devices, and prime movers where steps of the method include

establishing mover x/y values through any speed of rotation and degree of wide open mover flow curve (Fig. 6, 6a);

establishing terminal device x/y values through any degree of closure and Total Pressure constant (Fig. 11);

coordinating flow-pressure data through plotted curves of primary mover (11), system (5), and terminal device (3) performance characteristics;

processing output signals from flow-pressure monitor stations (2, 4);

interpolating these signals through the processor (9),

where sensed x/y (volume/pressure) values are coordinated to depict the actual operating point (10) of the mover-system (11, 5) to that assigned on the Cartesian graph (6);

displaying the intended operating point (10) as juxtaposed next to where sensors (2, 4) indicate actual values exist so that an output to a panel display (6) may be observed for comparison.

273. (New) The method of claim 272 wherein the mover driven RPM is metered to establish in memory the mover constant (11) with corrected BHP obtained from current readings of the electric motor powering the mover.

274. (New) The method of claim 272 wherein the mover curve (11) is plotted along its exact driven RPM against a given system (5) or some load with resistance where x/y (volume/pressure) are assigned values;

and displaying the operating point (10) indicating where the system curve (5) intersects with the mover curve (11) or valve constant (11);

at a given pressure and flow-volume as monitored by the prime mover sensor station (2) for the system total (5);

at a given pressure and flow-volume as monitored by the terminal device sensor station (4) for its terminal branch run (5) for the system terminal.

275. (New) The method of claim 272 wherein the system curve (5) is plotted at one or more mover speeds (11) or valve constants (11) to establish additional verification points (10) for plotting the extent of the system curve (5) or sub-system curve (5).



276. (New) The method of claim 272 wherein mover performance curves (11) and system curves (5) are projected by affinity relationships where no other data is made available when there are missing links in the curve;

by plotting one or more additional coordinates of the system (5) where the x value (flow) is squared to the y value (pressure);

by plotting one or more additional coordinates of the mover curve (11) where the mover rpm (11) is cubed to its corrected BHP (y value).

277. (New) The method of claims 272-276 serving automatic or default mode, the method including the steps wherein

mover x/y values are established through any speed of rotation and degree of wide-open mover flow curve (Fig. 6, 6A);

mover speed control (7) is effected to adjust the actual x/y values of the primary mover constant (11) against the system constant (5) as per total and specific pressures sensed (13, 14, 15) versus target operating point designated (10);

damper x/y values are established through any degree of closure and Total Pressure constant (Fig. 11);

damper actuation (3) is effected to adjust the actual x/y values of the valve constant (11) against its sub-system constant (5) as per total and specific pressures sensed (13, 14, 15) versus target operating point designated (10);

and stop or start motor speed control (7) or damper control actuation (3) to approach the coordinates of the intended operating point (10);

placing the actual operating point (10) where designated, or within its own suggested operating range (12);

adjusting the actual operating point (10) x/y values to meet in closest measure those coordinates of that operating point (10) targeted.

278. (New) The method of claim 277 wherein

when Total Pressure (TP) is lost or gained as monitored by the primary mover's flow-pressure monitor station (2), the variable mover (7) increases or decreases rotational speed (7) to adjust this measure in exact proportion to what was lost or gained, using its Total Pressure sensors (13), its Static Pressure sensors (14), or its Velocity Pressure sensors (15) as appropriate.

279. (New) The method of claim 273 and 278 wherein

a comparison is drawn of electrical Total Wattage as it parallels Total Pressure and the y value is calibrated by calculated BHP as obtained from current readings of the electric motor operating the primary mover (7) with corrective calibration of the y value or y factor along the mover curve, and corrective calibration of the mover curve therewith.

280. (New) The method of claim 272 wherein the x value is adjusted to ride the plotted system curve (5) with any increase in y value (or changes to the mover, 11) so increase is not directly related or vertical;

where value changes to a mover constant (11) or a system constant (5), but not both, ride the other's curve;

where either x or y values are adjusted to stay along these tangents (x/y or y/x).

281. (New) The method of claims 272-276 serving terminal device automatic or default mode, wherein

damper x/y values are established through any degree of closure and Total Pressure constant (Fig. 11);

modulating the terminal device damper-actuator (3) within a distribution system (5) to either open or close with net pressure gains/losses (4), and

placing its own sub-system operating point (10) on target with its valve constant (11) or in the suggested operating range (12) as per design or previously set criteria.

282. (New) The method of claims 272-276 operating in a Variable Volume System (24) with a plurality of terminal devices (3) wherein

the Initial Point of Operation (10) and range parameters (24) are established through flow-pressure monitor sensor input (2, 4) when:

the primary mover (1) is started and sped (7) to its target maximum rpm setting (11) at the designated total flow-volume as monitored at the main flow station (2);

all variables (3) are indexed to their starting maximum positions and the maximum critical run operating point (10) on the system curve display (6) is marked off on the graph;

the primary mover (1) is then slowed (7) to its target minimum rpm setting (11);

all variables (3) are indexed to their minimum positions and the minimum critical run operating point (10) on the system curve display (6) is marked off on the graph;

and a total system cutoff or constant (23) is established for the entire operating range of the variable speed mover (7) and its variable system (24), outlining an effective range and critical boundary of variable mover-system performance.

283. (New) Furthering the method of claim 282, during Variable Volume System operation, wherein

variable operating parameters (24) and point of operation (10) are tracked and adjusted automatically, whereby mover (11) and terminal devices (3) modulate to constant settings (10), varied settings (24), or default (suggested) settings (12);

by sorting terminal runs (5) from least to most critical by way of flow-pressure sensor input values (4) from a plurality of terminal devices (3) throughout a distribution system (5);

by placing those terminal devices (3) and their runs (5) most critical in their suggested ranges (12) or maximum positions as necessitated;

and applying mover power (7) to maintain adequate Total Pressure against a required flow rate to any terminal device (4) that becomes most critical under modulation;

and placing those terminal devices (3) and terminal runs (5) least critical in the percentile amount designated for system diversity (22);

and placing those terminal devices (3) and terminal runs (5) least critical in their minimum or closed positions;

and by allowing mover-terminal operation to remain only within established boundaries (23, 24) or suggested operating ranges (12).

284. (New) The method of claim 283 wherein the primary mover applies a “Mover Total Pressure” (20) against a terminal device Total Pressure loss.

285. (New) The method of claim 283 wherein the primary mover applies a “Unit Total External Pressure” (21) against a terminal device Unit Total External Pressure loss.

286. (New) The method of claims 272-276 serving the mode of Series Operation (16, 18) where steps include

activating a secondary mover in series (16) or a secondary damper in series (18) with the distribution system (5) when system velocity increases ( $V_p$ ) occur as would be caused by an opening damper, valve, or bypass-relief (3) on a terminal branch (5);

throttling the the main damper control (3) to create an artificial Static Pressure increase to meet and maintain the deviated operating point (10) against its incremental x/y value or y value (SP) alone as sensed at flow-pressure monitors (2, 4).

287. (New) The method of claims 272-276 serving the mode of Parallel Operation (17, 19) where steps include

activating a secondary mover in parallel (17), a secondary damper in parallel (19), a relief opening, a bypass, or a secondary source of flow in parallel with the distribution system (5) when system static increases (SP) or Static Regain occurs and, thus, a dynamic decrease;

thus meeting and maintaining a deviated operating point (10) against its incremental x/y value or x value ( $V_p$ ) alone as sensed at flow-pressure monitor stations (2, 4).

288. (New) The method of claims 286 and 287, wherein

when Total Pressure (TP) is lost or gained as monitored by the primary mover's flow-pressure monitor station (2), the variable mover (1) increases or decreases rotational speed (7) to adjust this measure in exact proportion to what was lost or gained, using its Total Pressure sensors (13), its Static Pressure sensors (14), or its Velocity Pressure sensors (15) as appropriate.

289. (New) The method of claims 272-276 where the said method serves a user interactive mode of operation wherein data is manually entered,

adjusting x/y values corresponding to flow-pressure sensor values (2, 4);

programming and placing the point of mover-system operation (10) where desired by user intervention;

effecting motor RPM and/or motorized damper control on command to specifically alter x/y coordinates of the operating point or points (10);

to design, test, calibrate, or operate a constant or variable volume system;

to view output display data (6) of mover, system, terminal device, or heat transfer performance (8) for observation, testing, design, estimation, or any other purpose.

290. (New) The method of claim 289 wherein

the system (5) may be manually altered, fitted, or re-fitted to relocate the operating points (10) or operating parameters (23, 24).

291. (New) The method of claims 272-276 wherein

an open input port to the processor (9) receives input from zone sensors or other external input to effect motor control of mover (7) or terminal devices (3) as per local network or thermostatic control,

thus activating motor control in the mover (7) or terminal device (3) and placing the system or sub-system (5) in its appropriate point of operation (10) as required or set by default, temperature or other set point.

292. (New) A method for determining heat transfer in heat exchangers, steps comprising

metering the primary mover (1) and system (5) total air volume (2) at given pressures;

metering same airflow dry and wet bulb temperatures in and out of heat exchanger;

metering heat exchanger (8) total fluid volume for standard water (GPM) or other corrected fluid volume with terminal device (3) at return piping of heat exchanger (8);

correcting for densities, specific heat, and specific gravity;

calculating the total heat exchanged from the fluid side of the heat exchanger;

calculating the final total, latent, and sensible heat exchanged from the air side of heat exchanger;

and displaying the data on the user interface for observation (6).

293. (New) A method for determining heat transfer and heat exchange effectiveness in energy recovery units, steps comprising

metering the supply air-fluid volume (2) at given pressures;

metering same supply with airflow dry and wet bulb temperatures;

metering the exhaust or return air-fluid volume (2) at given pressures;

metering same exhaust or return with airflow dry and wet bulb temperatures;

correcting for densities, specific heat, and specific gravity;

calculating the total mass flow rate of both air-fluid streams across heat exchange medium;

calculating the final total, latent, and sensible heat exchanged;

calculating percentage of heat exchange effectiveness expressed as a ratio;

and displaying test data results on the user interface (6).

294. (New) A method for controlling axial mover-system performance wherein

a terminal device control damper (3) is throttled against axial mover discharge flow,

adjusting damper control to specific damper positioning or valve constants (11);

applying specific mover constants (11);

and increasing BHP (Brake Horse Power) and system pressure at specific operating points (10).



295. (New) A method for controlling axial mover-system performance wherein

through motor control actuation, axial mover fan blade pitch angle (11) is increased or decreased, attaining specified mover constants (11) and flow-pressure rates (2) at a given blade angle, BHP, and specific operating point (10).

296. (New) The method of claim 290 wherein diverging or expansion fittings (5) are ducted to any mover to increase system Static Pressure;

and wherein converging or reduction fittings (5) are ducted to any mover to increase system Velocity Pressure.

297. (New) The method of claims 294 and 296 wherein an axial mover is ducted to a diverging or expansion fitting member (5) with a dampering device (3) adjusted to optimal (10) mover and valve constants (11), achieving peak system pressure and BHP.

298. (New) The method of claim 296, wherein the diverging or converging fitting befits any mover's Total Pressure, whereby

the diverging fitting meets the mover's net static power through effective duct diameter dimensional data;

whereby the converging fitting meets the mover's net velocity power through effective duct diameter dimensional data.

299. (New) An apparatus in accordance with claim 1 for mixing airstreams and adjusting percentages of OA/RA (Outdoor Air/Return Air) content in air distribution systems (FIG. 4) which comprises

a ducted mixing box housing fitted with dual damper control (3) and sensing stations (4) in parallel operation (19);

an actuation means of modulating open or closed, allowing both air streams to be throttled and mixed in particular proportions of Outdoor Air primary air quantity and Return Air secondary air quantity at operating conditions set (10) and maintained as per flow-pressure monitor sensor input (2, 4).

300. (New) A method for controlling Outdoor Air and Return Air content in air distribution systems wherein Total Air quantity is first determined at the main flow-pressure sensing station (2), and

Outdoor Air content of Total Air is monitored at its terminal device (4);

Return Air content of Total Air is monitored at its terminal device (4);

the Outdoor Air damper is modulated to increase or decrease OA content accordingly to the design value set;

the Return Air damper is modulated to increase or decrease RA content accordingly to the design value set;

a calculating step is performed wherein OA/RA values are deducted from Total Air (2);

Mover Total Pressure losses (20) are compared against Unit Total External losses (21) to surmount any internal or System Effect losses;

applying mover power (7) as needed to maintain the operating conditions (10) and the total system constant (5);

and applying mover power (7) as needed to maintain the operating conditions (10) and the sub-system constant (5) of the OA or RA terminal.

301. (New) The method of claim 300, wherein if the OA value falls below the design rate and the OA terminal device (3) is in its maximum position, the RA damper may close incrementally to produce an increase of OA as deducted from Total Air (2);

applying mover power (7) as needed;

maintaining the operating conditions (10) and the system constant (5) and the sub-system constant (5) of the OA terminal.

302. (New) A method for determining percentages of OA/RA content of Total Air by multi-point temperature sensing wherein

dry and wet bulb temperatures of OA/RA air streams are measured independently prior to entering the mixing box;

dry and wet bulb MA (Mixed Air) temperature is measured inside the mixing box through a multi-point traverse where air is not stratified;

a calculating step is performed to determine enthalpy of each air stream;

a calculating step is performed to determine percentages of OA/RA content of Mixed Air, where any of the unknowns: OA, RA, or MA data are solved for;

and the unknown percentage thus solved is applied to the Total Air figure as data obtained from the main flow-pressure monitor station (2), as an OA or RA percentage of the Total Air.

303. (New) A method in accordance with claim 302 for determining coil or heat exchanger loading wherein

a calculating step is performed to determine the Mixed Air enthalpy ( $H_m$ ) with percentages of OA and RA content and dry and wet bulb temperatures;

comparing the previous step with same multi-point readings downstream of the heat exchanger (8);

determining total flow from the flow-pressure monitor (2);

performing a calculating step to determine total, latent, and sensible loads on the heat exchanger (8).

304. (New) A method in accordance with claim 303 for controlling loading characteristics of the heat exchanger (8) comprising the steps of

modulating dual damper control of the mixing box;

adjusting OA and RA content, or primary and secondary air streams comprising Total Air content,

altering the value of Mixed Air enthalpy by decreasing OA or RA individual air stream content,

thus incurring latent or sensible changes;

and providing specific conditions of total, latent, or sensible heat exchange as displayed on a psychrometric chart (6);

thus following the vectorial lines of the chart as depicted in accordance with thermal dynamic relationships.

305. (New) A method for engaging building Smoke Mode Operation with air distribution systems wherein the Outdoor Air primary air damper is opened to 100% and the Return Air secondary air damper is closed to 0% for smoke mode purge operation, thus injecting 100% Outdoor Air primary air into a vessel or building envelope;

applying appropriate ACH (Air Changes per Hour) required to dilute total air of smoke content within a given period of time;

applying mover power (7) as needed to maintain the operating conditions (10) as varied or fixed;

and maintaining necessary system total constancy (5).

306. (New) A method in accordance with claim 305 for engaging building Smoke Mode Operation with air distribution systems wherein building exhaust distribution systems are activated to provide exhaust air movement relative to atmosphere for smoke evacuation from a vessel or building envelope in coordination with primary air injection;

applying appropriate ACH (Air Changes per Hour) required to evacuate total air of smoke content within a given period of time;

replacing total air content with adequate Primary air or makeup air changes;

maintaining a ratio of a minimum of 80% makeup air to 100% exhausted air;

applying mover power (7) as needed to maintain the operating conditions (10) as varied or fixed;

and maintaining necessary system total constancy (5).

---



Daniel Stanimirovic, Sole Inventor